# PERIODIC AND APERIODIC VARIABILITY OF THE INTERACTING BINARY AND LONG–PERIODIC STARS

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Recent results obtained within the framework of the international observational and research campaigns are reviewed. The main topics are following:

*magnetic cataclysmic variables:* synchronization of the spin and orbital period of the white dwarf; observational evidence on the switching of the accretion from one pole to another; non-dipole configuration of the magnetic field; "swingings" of the orientation of the magnetic axis in the "synchronous systems"; instability of the accretion and the "red noise"; long-term luminosity changes; UV Cet – like flares; two-pole accretion in the intermediate polars;

*weakly- and non- magnetic cataclysmic variables:* negative and positive superhumps in the nova–like variables; "red noise" and/or quasi–periodic oscillations; unprecedented switch of the superhump period in TT Ari; the luminosity dependence of the superhump period in BZ Cam and V725 Aql; long-term variations of the outburst characteristics of dwarf novae and luminosity of old novae – magnetic activity of the red secondary vs third body orbiting around a cataclysmic variable;

*symbiotic binaries:* light curve variations in symbiotic novae and stars with a pulsating component;

*long–periodic pulsating variables:* statistical study of the characteristics of the mean phase curves and of the individual cycles; additional classification criteria for the Mira–type and semi–regular stars.

Some of the original papers are available at *http://www.paco.odessa.ua/~il-a* and *http://il-a.pochtamt.ru*

## INTRODUCTION

The variety of physical mechanisms taking place in stars leads to a variety of their observational appearance. Thus, a monitoring study of long–term variations of the characteristics of variability is needed, which may give an important information on the structure and evolution of the underlying objects, in addition to the short–term studies at different instruments. A year–scale cyclic or aperiodic modulation is observed in magnetic and non–magnetic cataclysmic binary systems, in symbiotic binaries and long–period pulsating variables.

In this review, we list the highlights of the study carried out by the authors and we point out some problems, which are the subjects for further investigations.

Invited paper.

## MAGNETIC BINARY SYSTEMS: POLARS

AM Her–type stars, or polars, are characterized by a strong magnetic field of the white dwarf capturing the accretion flow and preventing the disk formation. The standard model and its extensions have been discussed by Andronov (1987).

AM Her has been monitored photometrically since 1978 and polarimetrically since 1989. The 186-min spin-orbital variability was studied by using various complementary methods. Long-term variations of the shape of the light curve were found, which are caused by switches of luminosity between high, intermediate and low states. The amplitude either of the orbital variability, or the "red noise" variability, statistically depends on luminosity, being the largest in the intermediate state.

The interrelations between the luminosity, colors of the mean flux, orbital and "red noise" variability will be discussed separately.

The following linear ephemeris was derived by using 267 photometric minima from various sources, which cover 65097 cycles (1976-1999): $MinHJD = 2446637.05101(\pm 0.00058) + 0.12892711(\pm 3\times 10^{-8})\times(E-28096)$. Here the initial epoch is close to the mid–observations and thus is much more accurate than that corresponding to the zero's cycle length.

The polarimetric ephemeris is based on the 19 main minima of the circular polarization in R: $HJD = 2450304.83379(\pm 0.00043) + 0.128927088(\pm 66\times 10^{-9})\times(E-56545)$.

There are cyclic variations of the phase with an effective cycle duration of $977-1288^d$, thus the seasonal value of the period may vary by $5\times 10^{-5}P$. These changes are interpreted within the "swinging dipole" model (Andronov, 1987) of cyclic 2D variations of the orientation of the magnetic axis (both in longitude and latitude) of the white dwarf in respect to the line of centers.

The characteristics of the outbursts produced by the accretion events and the UV Ceti – type flares in AM Her, QQ Vul and BY Cam have been discussed separately (Halevin *et al.* (this volume), Bonnet–Bidaud *et al.* (2000), Shakhovskoy *et al.* (1993, 1999), Andronov (1999)). The spectral characteristics of AM Her at a low luminosity state as well as at an intermediate outburst have been discussed by Silber *et al.* (1996) based on the ultraviolet (IUE) and optical photometry.

## MAGNETIC BINARY SYSTEMS: SYNCHRONIZING POLARS

Strong magnetic field of the white dwarf leads to a synchronization of its rotation with the orbital motion with the characteristic time scale of $\tau < 10^3$ years (Andronov, 1987). Nowadays, four slightly asynchronous polars are known. The most extensively studied object of this class is BY Cam, which was monitored from 1989. The observations completed during the "Noah project" (Silber *et al.*, 1997) and reanalyzed by Mason *et al.* (1998) have confirmed the asynchronism and have shown the "switches" of the accretion from one pole to another because of the "idling" of the white dwarf in respect to the red secondary. The characteristic time of the synchronization $\tau = 880 \pm 34$ years well agrees with the theoretical estimate.

Another asynchronous polar V 1500 Cyg (Nova Cygni 1975) was monitored since the explosion in 1975. Such a long–term database has allowed to detect variations of the rate of synchronization from $\dot{P}_{rot} = 1.8\times 10^{-6}$ in 1977-1979 to $\dot{P}_{rot} = 2.7\times 10^{-8}$ years. The last value corresponds to a characteristic time of 230 years (Pavlenko and Malanushenko, 1995). This allows to study a fine structure of the synchronization process.

## MAGNETIC BINARY SYSTEMS: INTERMEDIATE POLARS

Circular polarization in two intermediate polars (RX J2107.9-0518 (=HU Aqr) and RX J0558+5353 (=V405 Aur)) was detected by Shakhovskoy and Kolesnikov (1993 and 1997, respectively). During the polarimetric period occur two photometric waves with a nearly same shape. This can be interpreted in terms of the model of two accretion columns located diametrical opposite above the surface of the magnetized white dwarf. The circular polarization crosses zero, when the column is effectively perpendicular to the line of sight. At this time, the brightness reaches its maximum. This argues either for the variations of the column's projected surface area, or for the minimal occultation of the column by the white dwarf. A small difference in the shape of the photometric pulses, as well as a small mean polarization argues for a small angle between the magnetic axis and the equator plane of the white dwarf, of about few degrees. This situation is opposite to classical polars, where the magnetic axis is usually well inclined to the orbital plane (Brainerd and Lamb, 1985).

## SUPERHUMPS IN DWARF NOVAE: DEPENDENCE ON PERIOD AND LUMINOSITY

Dwarf novae are characterized by the outbursts with a cycle ranging from few days to few months or even years. The duration of this cycle, for a given star, may differ by few dozens per cent. Additionally, the so-called "supermaxima" (brighter and wider outbursts) are occurred in some binary systems, mainly with periods of

$\leq 2$ hours. During these brighter and wider outbursts the photometric waves called the "superhumps" may be observed (*cf.* Warner, 1976). Only few groups in the world (in Japan, USA and our group in Ukraine) attempt to find the superhumps by using CCD in the stars, which are to be supposed to have superoutbursts. The period of superhumps $P_{sh}$ is usually longer than the orbital one $P_{orb}$ with a relative difference increasing with $P_{orb}$. Because of scatter, there are various forms of the $P_{sh}(P_{orb})$ relation. One of them is $\log P_{sh} = -0.0043(\pm 0.0033) + 1.077(\pm 0.006) \log P_{orb}$ (with a corrected zero–point) (Andronov, 1990). Here $P_{sh}$ and $P_{orb}$ are expressed in hours.

The superhumps are explained by the rotation of the elliptic accretion disk which is slower than the orbital motion. The spin/orbital resonance occurs in short–period cataclysmic variables owed to a low mass ratio (Whitehurst and King, 1991).

However, the observations have shown that the superhump period undergoes changes with luminosity. During a superoutburst in V725 Aql, the superhumps were detected with a period decreasing with luminosity from 160 to 80 minutes. This phenomenon was interpreted by a decrease of the rotational period of the tilted accretion disk with decreasing radius (Baklanov *et al.*, 2000). It is very interesting to note a similar dependence obtained for another *nova–like* star BZ Cam (Andronov *et al.*, 2000). The "switch" to a "negative superhump" at minimum was detected in other dwarf Nova V503 Cyg (Kuznetsova *et al.*, 1999).

Thus, the photometric period depends not only on the orbital period (despite at the superoutburst maximum, it depends statistically on $P_{orb}$), but on the luminosity as well. In this case, the photometric wave is caused by the rotation of the inhomogeneous disk rather than by the rotation of the "quasi-stable" disk. Further monitoring of the evolution of superhump during a decline is necessary for other SU UMa nova–like stars.

## MULTI–CYCLIC ACTIVITY IN NON–MAGNETIC NOVA–LIKE BINARY SYSTEMS

Nova–like binary systems are cataclysmic variables with a high accretion rate leading to their "permanent outburst" state, which is rarely interrupted by excursions to a low or intermediate luminosity state.

*TT Ari* is the brightest object from this class and thus most extensively observed since 1965. One of the most prominent properties is the presence of quasi–periodic oscillations with a cycle length ranging mostly between 15 and 30 minutes. Recent studies (Tremko *et al.*, 1996; Andronov *et al.*, 1999) have shown that these variations occur at preferred time scales without a trend previously suggested. The power spectrum at higher frequencies obeys a power law with an index $\gamma_S = 1.51 \pm 0.04$ corresponding to a "red noise" often observed in accreting binaries. For different runs, the value of $\gamma_S$ is ranging from 1.3 to 2.6.

The photometric period differs from the orbital one, being shorter, thus arguing for the so–called "negative superhumps". In different years, its value was ranged from $0\overset{d}{.}1326$ to $0\overset{d}{.}133160$ showing its uncoherency (Andronov *et al.*, 1999).

However, Tremko *et al.* (1996) predicted a value of the superhump period $P_{sh} = 0\overset{d}{.}1493 \pm 0\overset{d}{.}0007$ using the "orbital period – superhump period" relation by Andronov (1990). This value was justified in 1997, when the superhump period changed to $P_{sh} = 0\overset{d}{.}14926 \pm 0\overset{d}{.}00005$ (Skillman *et al.*, 1998). This switch has shown an existence of two types of disk motion in respect to the rotating frame: apsidal advance ("negative superhump") and nodal regression ("positive superhump").

The difference between the photometric and spectral periods may lead to a beat phenomenon corresponding to the period of changes of the orientation of the disk in respect to the red dwarf secondary. However, its amplitude is estimated to be twice smaller than of the primary photometric wave itself (Andronov *et al.*, 1999).

Another interesting phenomenon observed in TT Ari is the systematic trend of the effective colors of the mean flux, superhump variability and quasi–periodic oscillations towards higher color temperatures (Tremko *et al.*, 1996; Efimov *et al.*, 1998).

Kraicheva *et al.* (1999) confirmed the suggestion of Bianchini (1990) about the presence of 6–year cycle in the luminosity variations of TT Ari.

Such complicated behaviour needs extensive observational studies with an annual monitoring of a total duration at least $\approx 100$ hours to study the origin of superhumps and other physical mechanisms causing variability at time scales from seconds to years.

Another nova–like system, *BZ Cam*, is usually in the state of a "permanent outburst". In 1999/2000, it underwent weakening by $\approx 1\overset{m}{.}3$ with slow decline and more rapid return at a rate $(28 \pm 2)$ days/mag in February-March, 2000. The primary photometric period usually interpreted as superhumps was variable, showing a statistical dependence $d \log P / d \log L = 1.0 \pm 0.2$ rather than a "switch" from a "negative" to "positive" superhump (Andronov *et al.*, 2000). The proposed interpretation was a response of the effective radius of the accretion disc on luminosity (*i.e.*, the mass transfer rate). Such a dependence resembles that described above for dwarf novae and thus shows a common origin of the photometric wave, despite these systems are located from different sides of the "2–3 hour period gap". This phenomenon is an excellent probe for the theories of non–stationary accretion discs and should be extensively studied.

**"NON–MAGNETIC" (?) DWARF NOVAE**

Dwarf novae are characterized by changes of the outburst cycle up to few dozens per cent. However, two types of possible season-to season changes can be occurred:

a) smooth variations of the cycle length (Bianchini, 1990);

b) abrupt switchings (Andronov and Shakun, 1990).

To study this phenomenon, the photographic observations on the negatives from the Odesa and Moscow plate collections were used as well as the visual estimates from the AFOEV and VSOLJ databases.

The star which is extensively covered by the observations is EM Cyg. The cycle of $3000^d$ in the cycle length variations, the amplitude and the mean brightness level have been discovered from the seasonal mean light curves by Andronov and Chinarova (1996) and then have been confirmed by using the data run covering 220 individual maxima and applying the wavelet analysis. The amplitude is correlated with the mean magnitude, thus the star shows only minor variations of the brightness at maximum at this timescale (despite the cycle–to–cycle changes are quite large from $11^m_.9$ to $13^m_.0$), despite the brightness at minimum shows a well pronounced $\sim 3000^d$ wave. The mean value of the cycle length is $25^d$, the mean outburst curve shows an ascending branch of a duration of $10^d$, whereas the descending branch lasts $14^d$. The mean amplitude is $1^m_.16$. The two main timescales of $25^d$ and $3000^d$ are in a good agreement with the optimal values of the filter half–width $\Delta t = 8^d$ and $1340^d$ obtained from the "running parabola" fits. The standstills at the light curve are present, during which the amplitude decreases drastically, confirming the UGZ classification of the star. One may note that the orbital period of EM Cyg is equal within few per cent to that of the prototypes of different subclasses of dwarf novae – SS Cyg and Z Cam.

In 5 other stars of the UGSS subtype, the few year–scale variations of the cycle length are found.

Such drastic changes of the cycle length are usually explained by variations of the accretion rate caused by a magnetic activity of the red dwarf (Bianchini, 1990; Andronov and Shakun, 1990). As an alternate explanation, one may suggest minor changes of the orbital separation owed to a third body orbiting near the cataclysmic binary. This model is indirectly confirmed by North (1999), who reported on a presence of a third star in EM Cyg. It would be desirable to make a more detailed study of this system and of similar objects.

**SYMBIOTIC VARIABLES**

The own photographic and the AFOEV and VSOLJ visual observations of the symbiotic variables R Aqr, TX CVn, UV Aur, V1016 Cyg, V 1329 Cyg are used for the time series and correlation analysis by applying the same methods to the systems with different types of variability are compared. The "scalegram" analysis is made by using the "running parabola" methods (Andronov, 1997) by the least–squares extension of the wavelet analysis (Andronov, 1998). The method of "running sines" (Chinarova *et al.*, 1994) allowed to study the slow variations of the mean, amplitude and phase of the pulsations. In the objects studied, these characteristics vary with time. Among the highlights are following:

*UV Aur.* The main oscillation with the period $P = 393^d_.0 \pm 0^d_.1$, full amplitude $1^m_.32 \pm 0^m_.02$ and asymmetry $0.43 \pm 0.01$ is superimposed onto a long–term variation with $P_2 = 6800 \pm 46^d$ and a full amplitude $1^m_.20$. Suggesting that $P_2$ is a beat period between the orbital period $P_{orb}$ and the pulsational period $P_1$, one may estimate $P_{orb} = 371^d_.5$ (Chinarova, 1998). This suggestion of the beat phenomena in symbiotic binaries is to be checked.

*TX CVn.* The main oscillation with a characteristic cycle length of $500^d$ is characterized by highly variable semiamplitude from $\approx 0^m_.2$ to zero within error estimate. This is characteristic for transient pulsations which may be caused by the red giant. A longer wave is characterized by a cycle length varying from $\approx 2000^d$ to $\approx 6000^d$.

*V 1329 Cyg.* The photometric behaviour in 1891–1997 years was characterized by a drastic change from the light curve with narrow eclipses to a slightly asinusoidal type of variability with the ephemeris

$$MinJD = 2446771(\pm 3) + 956.5(\pm 0.6) \cdot E.$$

The amplitude in U ($1^m_.6$) is significantly larger than in the pg, B and V bands ($1^m_.22$). After the outburst, the trend is superimposed onto the brightness variations at a rate being maximal in U: $dm/dt = (100 \pm 4) \times 10^{-6}$ mag/day. Besides this, a secondary period with the ephemeris $MaxJD = 2446711(\pm 9) + 553.1(\pm 1.9) \times E$ and the semi–amplitude $0.075 \pm 0^m_.007$ is present, as well as a possible wave with a $\approx 5300^d$ cycle (Chochol *et al.*, 1999).

## "RED NOISE" IN ACCRETING BINARY SYSTEMS

Cataclysmic variables are characterized by a high level of fast aperiodic variability called "flickering" (*cf.* Warner, 1976; Bruch, 1992). It is usually interpreted by inhomogeneity and instability of the emitting accretion structures. The main sources are following: a) the superposition of the individual outbursts caused by the accretion of the plasma inhomogeneities with a high overlapping causing the "shot noise" and b) chaotic motion of massive blobs and chaotic changes of the accretion disc structure.

The power spectra of these variations show a systematic decrease with frequency which may be called a "red noise" contrary to the "white noise", which is statistically independent on frequency. In a double logarithmic scale, such power spectra often have nearly linear parts corresponding to a power law $S(f) = A \cdot f^{-\gamma_S}$. For infinite time series, the values of $\gamma_S = 0$, 1 and 2 correspond to a "white noise", "flickering" and "random walks", respectively.

To study this phenomenon, we have elaborated a few complementary methods taking into account a finite length of irregularly spaced data which are listed by Andronov (1999) and based on the periodogram, wavelet, scalegram and auto-correlation analysis. In more detail, they will be described in the monograph by Andronov (2000, in preparation).

Results of study of the selected stars are briefly summarized by Andronov (1999) and Andronov *et al.* (1999). The characteristics of this variability are strongly dependent on the luminosity state of a given star and are different for objects with periodic modulation (intermediate polars), quasi-periodic oscillations (nova–like variables) and polars.

## LONG–PERIOD PULSATORS

The statistical study of the characteristics of the individual pulsation cycles of 53 *Mira*–type stars has been carried out by using the visual observations of from the AFOEV and VSOLJ databases. Results of this study are presented separately in this volume by Marsakova and Andronov and will not be repeated here.

The periodogram analysis of 42 *semi-regular* stars was carried out. The algorithm was described by Andronov (1994). Three best fit frequencies were consequently determined for the original and "prewhitened" data. According to the periodograms and the shapes of the light curve, the stars may be preliminary subdivided into 5 groups:

1) "quasi-harmonic" (*e.g.*, T Ari with one dominating wave);

2) "quasi-multi-harmonic" (*e.g.*, U Del with 2 or 3 peaks at a periodogram corresponding to integer ratios of the period to a main one);

3) "multiperiodic" (*e.g.*, TX Dra with 2 or 3 periods differing by a few times);

4) "switching" periods (*e.g.*, AF Cyg with period ratio of 7/4);

5) "chaotic" (*e.g.*, X Her with a lot of peaks).

Possibly one may also distinguish the "modulated" stars (*e.g.*, S Per with highly variable amplitude of the main oscillation of a period by $\approx 10$ times smaller than the cycle of mean brightness and amplitude modulation);

All waves have variable amplitude and phase and sometimes some "switchings" occur from one wave to another (*e.g.*, AF Cyg). These groups are not coinciding with the GCVS types, allowing possible additional phenomenological classification.

## REFERENCES

[1] *Andronov I. L.* "Swinging Dipoles" in Magnetic Close Binary Systems // Astrophys. and Space Sci.–1987.–**131**.–P. 557–570.

[2] *Andronov I. L.* On "Orbital Period–Superhump Period" Relationship in Cataclysmic Variables of SU UMa-Type // Astron. Tsirk.–1990.–**1545**.–P. 15–16.

[3] *Andronov I. L.* (Multi-)frequency variations of stars. Some methods and results // Odessa Astron. Publ.–1994.–**7**.–P. 49–54.

[4] *Andronov I. L.* Method of running parabolae: spectral and statistical properties of the smoothing function // Astron. and Astrophys. Suppl. Ser.–1997.–**125**, N 1.–P. 207–217.

[5] *Andronov I. L.* Wavelet analysis of time series by using the method of least squares with supplementary weights // Kinematics and Physics of Celestial Bodies.–1998.–**14**, N 6.–P. 490–511.

[6] *Andronov I. L.* "Red noise" from the accreting magnetic white dwarfs // Astron. Soc. Pacif. Conf. Ser.–1999.–**169**.–P. 326–336.

[7] *Andronov I. L., Arai K., Chinarova L. L., et al.* A search for periodic photometric behavior in the cataclysmic variable TT Arietis // Astron. J.–1999.–**117**.–P. 574–586.

[8] *Andronov I. L., Chinarova L. L.* Outburst cycle length variations in the dwarf nova EM Cygni // Odessa Astron. Publ.–1996.–**9**.–P. 9–13.

[9] *Andronov I. L., Gazeas K., Kolesnikov S. V., Niarchos P. G., Shakhovskoy N. M.* Superhumps vs "red noise" in the cataclysmic binary BZ Camelopardalis in 2000 // Astronomy 2000: International Sci. Mem. Conf., Abstracts.–Odesa: Astroprint, 2000.–21 p.

[10] *Andronov I. L., Shakun L. I.* Alternating Cycle Durations in Dwarf Novae // Astrophys. and Space Sci.–1990.–**169**.–P. 237–240.

[11] *Baklanov A. V., Pavlenko E. P., Andronov I. L.* CCD and TV- photometry of cataclysmic variable stars // Astronomy 2000: International Sci. Mem. Conf., Abstracts.–Odesa: Astroprint, 2000.–21 p.

[12] *Bianchini A.* Solar-type cycles in close binary systems // Astron. J.–1990.–**99**, N 6.–P. 1941–1952.

[13] *Bonnet-Bidaud J. M., Mouchet M., Shakhovskoy N. M., et al.* Magnetic field and unstable accretion during AM Herculis low states // Astron. and Astrophys.–2000.–**354**.–P. 1003–1010.

[14] *Brainerd J. J., Lamb D. Q.* Orientations of AM Her stars from their polarization properties: the case of the missing AM Her stars // Astrophys. and Space Sci. Lib.–1985.–**113**.–P. 247–256.

[15] *Bruch A.* Flickering in cataclysmic variables: its properties and origins // Astron. and Astrophys.–1992.–**266**.–P. 237–265.

[16] *Chinarova L. L.* Time Series Analysis of the Periodic and Aperiodic Variations of the Symbiotic Star UV Aurigae // Proc. 29th Conf. Variable Star Res., Brno, Czech Republic / Eds J. Dusek, M. Zejda.–1998.–P. 38–44.

[17] *Chochol D., Andronov I. L., Arkhipova V. P., et al.* Long-term photometry of the symbiotic nova V1329 Cyg // Contr. Astron. Obs. Skalnate Pleso.–1999.–**29**.–P. 31–46.

[18] *Efimov Yu. S., Shakhovskoy N. M., Andronov I. L., Kolesnikov S. V.* UBVRI photometry and polarimetry of the cataclysmic variable TT Arietis // Izv. Krym. Astrophys. Obs.–1998.–**94**.–P. 263–266.

[19] *Kraicheva Z., Stanishev V., Genkov V., Iliev L.* TT Arietis: the 1985–1999 accretion disc behaviour // Astron. and Astrophys.–1999.–**351**.–P. 607–618.

[20] *Kuznetsova Yu. G., Pavlenko E. P., Sharipova L. M., Shugarov S. Yu.* Observations of typical, rare and unique phenomena in close binaries with extremal mass ratio // Odessa Astron. Publ.–1999.–**12**.–P. 197–200.

[21] *Mason P. A., Ramsay G., Andronov I., et al.* Evidence for pole switching in the magnetic cataclysmic variable BY Camelopardalis // Mon. Notic. Roy. Astron. Soc.–1998.–**295**.–P. 511–519.

[22] *North R. C.* EM Cygni: a compationable dwarf nova // Warner Symp. on Cataclysmic Variables, Cambridge, 1999.–P. 63.

[23] *Pavlenko E. P., Malanushenko V. P.* The peculiarity of V1500 Cyg synchronization // Astrophys. and Space Sci. Lib.–1995.–**205**.–P. 172.

[24] *Shakhovskoy N. M., Alexeev I. Yu., Andronov I. L., Kolesnikov S. V.* Unprecedented flare at red secondary component of AM Herculis // Annals of the Israel Phys. Soc.–1993.–**10**.–P. 237–240.

[25] *Shakhovskoy N. M., Andronov I. L., Kolesnikov S. V., Halevin A. V.* Blob parameters of accretion streams in magnetic cataclysmic variables // Odessa Astron. Publ.–1999.–**12**.–P. 242–244.

[26] *Shakhovskoy N. M., Kolesnikov S. V.* RXJ 2107.9-0518 // IAU Circ.–1993.–N 5891.–P. 1.

[27] *Shakhovskoy N. M., Kolesnikov S. V.* RXJ 0558.0+5353 // IAU Circ.–1997.–N 6760.–P. 1.

[28] *Silber A. D., Raymond J. C., Mason P. A., et al.* IUE and Optical Observations of AM Herculis in its Low State // Astrophys. J.–1996.–**460**.–P. 939–948.

[29] *Silber A. D., Szkody P., Hoard D. W., et al.* The Noah Project: detection of the spin-orbit beat period of BY Camelopardalis // Mon. Notic. Roy. Astron. Soc.–1997.–**290**.–P. 25–33.

[30] *Skillman D. R., Harvey D. A., Patterson J., et al.* Superhumps and accretion disk precession in TT Arietis // Astrophys. J. Lett.–1998.–**503**.–P. L67–L70.

[31] *Tremko J., Andronov I. L., Chinarova L. L., et al.* Periodic and aperiodic variations in TT Arietis. Results from an international campaign // Astron. and Astrophys.–1996.–**312**.–P. 121–134.

[32] *Warner B.* Observations of Dwarf Novae // The Structure and Evolution of Close Binary Systems, Dordrecht, Holland / Eds P. P. Eggleton, S. Mitton, J. A. Whelan.–1976.–P.85–140.

[33] *Whitehurst R., King A.* Superhumps, resonances and accretion discs // Mon. Notic. Roy. Astron. Soc.–1991.–**249**.–P. 25–35.